Beyond Restoration: Considering Emotion Regulation in Natural Well-being

Miles Richardson

Human Sciences Research Centre, University of Derby, Derby, UK.

CORRESPONDENCE: m.richardson@derby.ac.uk

Pre-print, for final version visit:
https://www.liebertpub.com/doi/abs/10.1089/eco.2019.0012

Abstract

Our relationship with the rest of the natural world can help emotional regulation, yet the role of nature in the regulation of emotions is often overlooked. As the health benefits provided by nature are increasingly recognised there is a need for accessible models that can explain and promote those well-being benefits. To complement existing theories based on restoration and to improve understanding of nature's role in emotional regulation, this article provides an account of the well-being benefits of nature based on affect regulation. The article considers the relationships between emotional regulation, well-being and nature through an accessible model of affect regulation that explains research reporting physiological responses to nature. The model, and underpinning research, highlight the interconnectedness between people and the rest of nature, fitting a wider narrative about the human role in our ecosystem. Applied implications of this perspective are presented.

Keywords: affect regulation; emotion; nature connectedness; nature; well-being

The role of nature in the regulation of emotions is often overlooked (Korpela et al. 2018). This is despite some recognition that our relationship with the rest of the natural world plays a role in the process of emotional regulation (Jordan, 2009; Johnsen et al. 2013). Given global issues in mental well-being (Frankish, Boyce & Horton, 2018; Chandra & Chand, 2018) and increasing acceptance of the benefits of nature, policies on connecting people with nature for well-being are emerging, for example in the United Kingdom's 25 Year Environment Plan (25YEP; H.M. Government, 2018). To inform such work there is a need to understand the mechanisms for the well-being benefits. Such knowledge allows various stakeholders to understand and promote the well-being benefits of nature, and a close connection to it, and develop effective interventions such as green and social prescriptions. More widely, in the context of the crisis in biodiversity (Ceballos et al 2017), it is important to provide narratives that show that nature matters for human well-being. To complement restorative theories and to aid the understanding and dissemination of nature's role in the successful affect regulation required for well-being, this article provides an account of the health benefits humans derive from the natural world based on maintaining well-being through emotional regulation and balance (WERB).

In addition to the health benefits provided by exposure to nature (See Maller et al. 2006; Russell et al. 2013 for reviews), the well-being benefits of nature connectedness, a close relationship with nature, are increasingly documented (Capaldi et al. 2014; Richardson et al. 2017). The dominant models that are often presented as explaining the well-being benefits of exposure to nature are based upon psychological restoration (Hartig et al. 2010). Attention Restoration Theory (ART; Kaplan, 1995) and Stress Recovery Theory (SRT; Ulrich et al. 1991) provide important accounts of why nature provides restoration for those who are experiencing stress or fatigue. However, early indications suggest that ART and SRT do not explain the benefits of nature connectedness (Capaldi et al. 2017; Gidlow et al. 2016). There is also research that has questioned ART with a review by Ohly et al. (2016) finding that several studies did not support ART. Joye & Berg (2011) also argue

against the psycho-evolutionary basis of SRT and suggest an account based on restoration through processing fluency. Further, it has also been noted that nature has beneficial effects when resources have not been depleted (Beute and Kort, 2014), with Johnsen et al. (2013) finding that people seek out nature for emotional regulation when happy and sad. However, emotion and affect regulation within the natural environment is often overlooked (Korpela et al. 2018), for example recent guidance on the pathways linking greenspace to health by Markevych et al. (2017) does not include emotion regulation.

In sum, the role of nature in emotion regulation is often overlooked despite evidence that people seek out nature for the regulation of emotions and evidence that restoration-based accounts do not explain all the well-being benefits derived from nature. This, together with the evidence presented below on the link between affect regulation and well-being provides a sound basis for an additional account of the well-being benefits of nature through emotional regulation and balance.

The Relationship between Emotional Regulation and Well-being

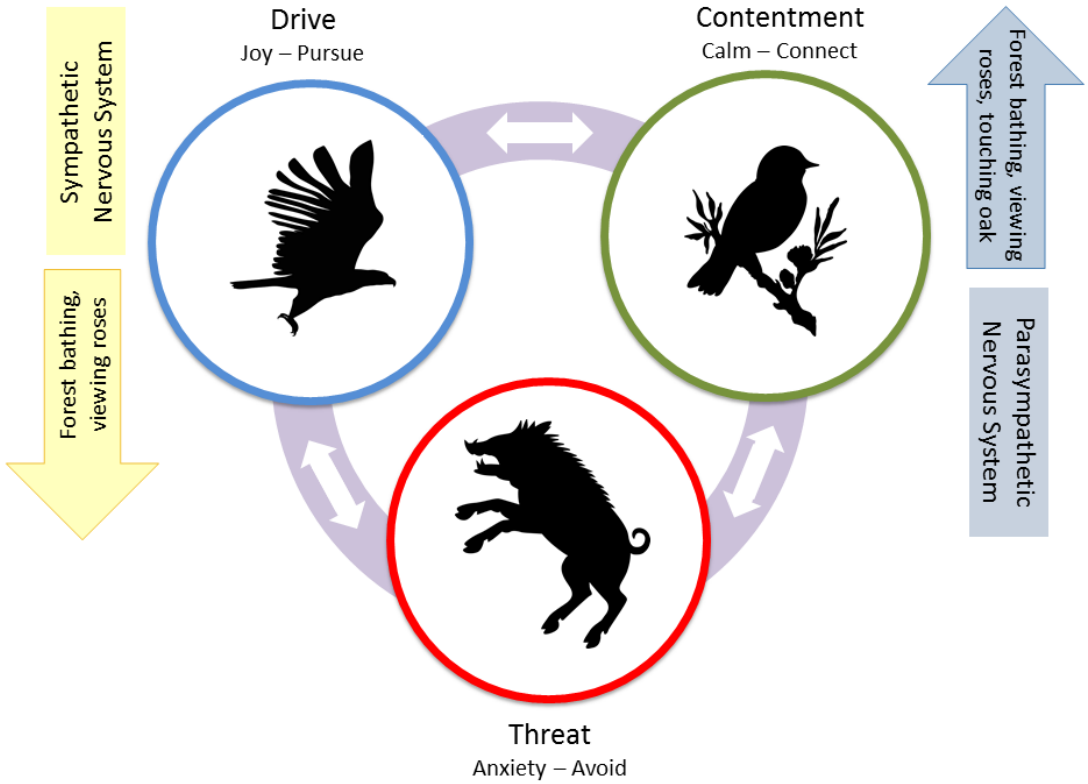
A body of research shows that successful emotional regulation is linked to health and well-being (e.g. Gross, 2013). In a review of emotion regulation, Gross (2013) presents the links between emotion regulation and decreased risk of coronary heart disease (Kubzansky et al. 2011). Similarly, DeSteno et al. (2013) present a number of pathways linking emotions and health, noting how emotions, and their regulation, are fundamental features of human function, rather than by-products of illness. As a fundamental human function, emotions alter the body's physiology (e.g. cardiac function, blood pressure, immune response), providing the potential to impact on health and well-being. DeSteno et al. present links between emotion regulation and a range of health outcomes including obesity, inflammation, and illness frequency, with negative emotions influencing the development of disease. Further, in certain circumstances, short-term adaptive physiological responses can lead to maladaptive outcomes in the long-term if emotions are not regulated correctly (Sapolsky, 2007). Beyond these direct effects, there are also many indirect effects of affect on health

as emotions impact the body in a manner that cognition cannot. For example, emotions provide the impetus for action and motivation (Gilbert, 2014) required for healthier behaviours.

The three-circle model of emotion regulation (Figure 1) was developed by Gilbert (2005; 2014) to support a new mental health therapy. As a model, the three-circle model is a simplification of the complex physiological process of affect regulation. It is used successfully in non-clinical settings, for example children in schools, to explain how the regulation of emotions are related to well-being. Given the context of wellbeing and the wider natural world, Figure 1 has been adapted with elements of nature used to represent both the three types of emotion (see drive, contentment and threat below) and the emotions nature may evoke. This is intended to provide an accessible model that helps explains how exposure to and a connection with the wider natural world affects our emotional regulation and mood. The circle of arrows represents the interplay between the emotions described by the accounts below. The arrows to the side summarise how the model can explain the positive physiological responses found from exposure to nature (Richardson et al. 2016; Chirico et al. 2017; Song et al, 2017). Namely, measured responses to forest bathing, awe inspiring natural beauty, and viewing beautiful roses. These results will be explained further, once the research underpinning the three-circle model has been introduced.

The model represents our affect regulation system in three dimensions based on affiliative and positive emotions (Depue and Morrone-Strupinsky (2005), threat system research by LeDoux (1998) and Panksepp (1998), and parasympathetic and sympathetic nervous system balance (Porges 1995). The three-circle model explains the experiences of drive, contentment, and threat. Drive (sympathetic activating) is required to seek out rewards and relates to positive feelings such as joy. The eagle is used to represent both drive and the joy one may feel on seeing an eagle. Contentment is affect-regulating and has an affiliative focus (parasympathetic activating), bringing positive soothing and regulating emotions such as calm which tone-down sympathetic activity. The bird at rest is used to represent both contentment and the calm one may feel when pausing to view a bird at rest. Threat

(rapid sympathetic activation) relates to our self-protection system and feelings such as anxiety. The wild boar is used to represent both threat and also the anxiety some may feel at an unexpected encounter with a wild boar.



It is important to remember that the interplay between these systems, represented by the circle of arrows in figure 1, is complex, producing blended patterns of positive affect, rather than one system increasing as another decreases. The long-standing account of two phases of positive states, appetitive activity 'doing' and consummatory response 'being' (Tinbergen, 1951), describes the balance between drive and contentment. Upon achieving a goal, drive systems need to be deactivated to balance energy expenditure and provide positive affect in the form of contentment. The drive system which brings feelings of excitement (Gilbert et al., 2008) is distinct from the contentment system which is seen as affect-regulating (Depue & Morrone-Strupinksy, 2005). Based on the work of Depue and Morrone-Strupinsky (2005), and mirroring the wakeful relaxation and positive emotional typology of Ulrich (1983), the model depicted in figure 1 suggests two broad types of positive affect - positive joy or the relaxed calm of contentment (Gilbert, 2014). During our states of

being and doing, we can encounter threats which result in rapid spikes of sympathetic nervous system activation as our bodies are readied for immediate action. As represented by the circular arrows in figure 1, the calming and soothing emotions of contentment tone down the threat and drive systems, bringing balance.

It is the *balance* between systems that produces different mood states and physiological responses. The physiology of the sympathetic and parasympathetic system and two branches of the vagal nerve are fundamental to affiliative behaviours and attachment that bring emotion-regulation (Porges, 2007). The balance between these systems is successful affect regulation, which as we've seen above is beneficial to health and well-being. Hence the three-circle model provides a narrative that the well-being benefits of nature go beyond restoration to wellness through emotional balance. The affect-regulation system controls our heart-rate, muscles, and the way our brain functions in order to achieve the balance required for well-being (Kappas, 2011). Therefore, one way of investigating the balance between parasympathetic and sympathetic systems, or between contentment, drive and, threat in the three-circle model, is by measuring heart rate variability (HRV). HRV is an established method for exploring changes in inhibitory parasympathetic activity and excitatory sympathetic activity that controls the heart. Within the context of affect regulation and well-being through nature, there is a body of HRV research into forest bathing analysed by Richardson et al. (2016). In a review and meta-analysis of 16 nature exposure studies that took HRV measures 14 indicated greater parasympathetic activity (contentment) and lower sympathetic activity (drive) in the nature exposure conditions. Thus supporting the three-circle model. Similar HRV results have been found by studies into the physiological response to awe inspiring natural scenes (Chirico et al. 2017), viewing beautiful roses (Song et al, 2017) and simply touching wood (Ikei et al. 2017). These results show how interaction with the natural world can lead to greater parasympathetic activity (contentment) and lower sympathetic activity (drive) and thus play a role in affect regulation that is often overlooked (Korpela et al., 2018). However, participant responses varied, providing

insight into the role of threat. Kobayashi et al. (2015) noted that 80% of people showed an increase in the parasympathetic activity, and 64% showed decreases in the sympathetic activity when forest bathing. Those remaining showed opposite responses. Kobayashi et al. (2015) note that some people report a strong dislike for natural environments, including specific phobias such as arachnophobia, which is known to impact on heart rate. Therefore, it is possible that some people asked to sit in the forest displayed a threat response that was then observed in the HRV measure.

The Relationship between Emotional Regulation and our Connection with Nature

Drawing on research in environmental psychology (see Korpela et al. 2018 for a recent review) people use natural environments to help maintain positive mood states and shift away from negative states. Jordan (2009) claimed that facets of our relationship to the natural world are central to the process of emotional regulation. There are further indications of a relationship between emotional regulation and connectedness to nature. Firstly, a facet of nature connectedness is based on our affective relationship with nature, where an individual has a close, emotional relationship with the rest of the natural world (Mayer & Frantz, 2004; Perrin & Benassi, 2009). Secondly, Fonagy (2018) explains how affect regulation plays a fundamental role in the sense of self; a second key facet of our connectedness with the wider natural world is the extent to which nature is included in our representation of self (Shultz, 2002). Third, exploratory research shows that the ease of emotional regulation mediates the relationship between nature connectedness and well-being (Richardson & McEwan, 2018). Given the lack of research into the relationship between emotional regulation and nature connectedness a broader perspective, beyond specific nature connectedness research, can also be considered. An emotion-based account of the well-being benefits of nature is supported by Johnsen and Rydstedt (2013) who found emotional benefits in those using nature for emotional regulation, with people seeking out natural environments offering potential for emotion regulation. Further, Kühn et al. (2017) report how people living close to woodland have higher structural integrity of the amygdala. The amygdala plays a key role in regulating emotional responses

and the processing of emotional information (LeDoux 1998; Phelps 2004). Finally, research showing the physiological response to awe inspiring natural scenes (Chirico et al. 2017), viewing beautiful roses (Song et al, 2017) and simply touching wood (Ikei et al. 2017) suggests a deep connectedness between people and nature.

Such a connectedness between people and the natural environment is in contrast to the Cartesian tradition of the object being seen as separate from the subject, but fits a phenomenological perspective (e.g. Merleau-Ponty and Lefort 1968) that has come to the fore, for example in recent theories of embodied cognition (Clark 1997; Clark and Chalmers 1998; Gallagher 2005; Lakoff and Johnson 1999; Thompson 2010). Further, Stevens (2010) presents an ecopsychological view of our embeddedness within the environment based on evidence of ever changing and continual two-way physical connections; electromagnetic, chemical and mechanical interactions that provide all we can know of the world. With the addition of research into restorative natural environments and the practices of ecotherapy, Stevens offers an alternative view of well-being, where the emphasis is shifted away from the individual and their illness and considers instead a more dynamic relationship between people and the wider environment. Stevens argues for a view of health where environment and human is a false dichotomy, just as we now understand mind and body cannot be seen as separate when promoting well-being. This has seen the 'biomedical' model of medicine expanded to the 'biopsychosocial' model (Engel 1977) and further suggests that health depends on a unity of biology, psychology and nature, a 'biopsychophysis' (Richardson et al. 2017; Van Gordon et al. 2018) where people are embedded within a dynamic relationship with the natural environment, rather than responding to it. This view is increasingly seen in models of health, for example the one health perspective (Rabinowitz et al. 2018). From the systems perspective of one health, the human need to maintain emotion regulation for mental health (Gross & Munoz, 1995) has clear parallels with the homeostasis, equilibrium, and balance required for a healthy ecosystem (Odum, 1985). Similarly, definitions of ecosystem health refer to absence of distress, stability, and resilience

(Tzoulas et al. 2007). Recognising these parallels helps affirm people's interconnected relationship within nature, just as other organisms have a symbiotic relationship with other parts of the ecosystem (e.g. Scherber et al. 2010), so do people.

Emotional Regulation and Nature for resilience and Well-being

The research above shows that successful affect regulation is linked to health and we've seen from the evidence above that nature has a physiological impact linked to our affect regulation system, with the three-circle model showing how interaction with the wider natural world can bring balance through activation of certain aspects of our nervous system. Bratman et al. (2015) note the potential of natural environments to service emotional regulation and suggest further research into how nature decreases maladaptive forms of regulation. While indicating the benefit of balanced emotional regulation, the perspective is based on a deficit model and how nature can restore, rather than maintain well-being and provide resilience. A resilience model is promoted by Tugade and Fredrickson (2007) who note that emotion regulation is essential to everyday life, and there is a need to maintain positive emotions in order to build resilience for well-being. They explain how emotion regulation through savouring can be used to extend positive emotional experiences with an impact on well-being. Such focus on positive emotions broadens thoughts and actions, building personal resources (Fredrickson, 1998). These positive emotions bring the resilience needed to bounce back from negative emotions and to adapt to the demands of stressful experiences. Hart et al. (2006) also present a resilience and balance based model accounting for well-being. The specific protective factors they identified were the experience of positive emotions and an adaptive form of emotion regulation with reduced negative emotionality. Recently, positive psychology interventions adapted to prompt people to notice the good things in nature have been found to increase nature connectedness and psychological well-being (Richardson & Sheffield, 2017). Indeed, many benefits of nature and nature connectedness are related to positive affect, albeit of a single dimension

(McMahan & Estes, 2015). WERB and the three-circle model remind us that nature brings two types of positive affect, both positive joy and the relaxed calm of contentment.

Finally, this perspective can provide insight into the mechanisms by which nature benefits health, as there is also evidence of a relationship between positive affect and immune function, with up-regulation of immune components among *healthy* people (Marsland et al. 2007). Kuo (2015) proposes that the benefits of nature for health come from enhanced immune function, rather than pathways related to stress, physical activity, air quality, and social integration. Kuo refers to studies that focus on the link between immune function and emotional regulation and notes the link between immune function and positive affect, which, as argued in this paper, is maintained through balanced emotional regulation.

In summary, research shows that affect regulation is linked to health, the three-circle model of affect regulation can explain research reporting physiological responses to nature exposure, and a rationale linking a close affective relationship to nature with emotion regulation is presented. Together, the evidence presented supports the three-circle based WERB account of the health and well-being benefits of nature through balancing emotional regulation. From this perspective, nature helps maintain positive emotions through greater resilience and enhanced immune function, therefore also providing a mechanism to explain the long-term benefits of nature exposure. Considering restorations based accounts of well-being through nature, the three-circle model includes the elements of SRT, so that restoration based account can be maintained alongside ARTs model of restoration from cognitive fatigue. The model, and underpinning research, highlight the interconnectedness between people and the rest of nature, fitting a wider narrative about human embeddedness in the ecosystem.

There are also applied implications of the account presented. In an increasingly urban world with growing demands on health services, public health can be improved through relational thinking about people and nature. Within this context, and policies on green prescriptions and increasing and

improving green infrastructure in towns and cities for well-being, it is important to provide explanatory mechanisms as they can inform policy and planning. Theories of well-being based purely upon psychological restoration can suggest the provision of pockets of green space and short-term public health interventions (e.g. green prescriptions) to enable urban dwellers to receive a dose of nature, resulting in the continuation of traditional relationships and a culture of occasional visits to *special* green spaces. The present paper suggests that there is a need for regular and sustained engagement with nature within a biodiverse landscape to maintain well-being and resilience. This has wider implications, from the need for networks of green corridors to help reverse the decline in biodiversity to cultural aspects of green cities, such as moving beyond exposure to purposefully engaging with nature (e.g. urban equivalents of forest-bathing and symbolic celebrations of nature across the seasons). Further still, the research supporting WERB can inform well-being beyond cities, the importance of beautiful and awe inspiring landscapes, and their role in emotional regulation and wellness. As an established model used in clinical practice, the three-circle based account underpinning WERB provides a convincing, yet easily accessible narrative, for researchers, but also to help influence decision makers and inform practitioners of the longer-term benefits of nature and human interconnectedness with nature. Given the crises in both mental well-being (Frankish, Boyce & Horton, 2018; Chandra & Chand, 2018) and planetary health (Ceballos et al 2017), narratives that show nature matters are important as we seek to improve the relationship between people and the rest of the natural world.

Author Disclosure Statement

No competing financial interests exist.

References

Beute, F. and Kort, Y.A. (2014). Salutogenic effects of the environment: Review of health protective effects of nature and daylight. *Applied Psychology: Health and Well-Being*, 6, 67-95.

Bratman, G.N., Daily, G.C., Levy, B.J. and Gross, J.J. (2015). The benefits of nature experience: Improved affect and cognition. *Landscape and Urban Planning*, 138, 41-50.

Capaldi C. A., Dopko R. L. and Zelenski J. M. (2014). The relationship between nature connectedness and happiness: a meta-analysis. *Frontiers in Psychology*, *5*. doi: 10.3389/fpsyg.2014.00976

Capaldi, C. A., Passmore, H. A., Ishii, R., Chistopolskaya, K. A., Vowinckel, J., Nikolaev, E. L., & Semikin, G. I. (2017). Engaging with natural beauty may be related to well-being because it connects people to nature: Evidence from three cultures. *Ecopsychology*, *9*, 199-211.

Ceballos, G., Ehrlich, P. R., & Dirzo, R. (2017). Biological annihilation via the ongoing sixth mass extinction signaled by vertebrate population losses and declines. *Proceedings of the National Academy of Sciences*, *114*(30), E6089-E6096.

Chandra, P.S., Chand, P. (2018). Towards a new era for mental health. *The Lancet*, 392, (10157). 1495-1496 http://dx.doi.org/10.1016/ S0140-6736(18)32272-4

Chirico, A., Cipresso, P., Yaden, D.B., Biassoni, F., Riva, G. and Gaggioli, A. (2017). Effectiveness of immersive videos in inducing awe: An Experimental Study. *Scientific Reports*, *7*, 1218.

Clark, A. (1997). *Being There.* MIT Press, Cambridge MA.

Clark, A., and Chalmers, D. (1998). The Extended Mind. *Analysis*, *58*, 7–19.

Depue, R.A. and Morrone-Strupinsky, J.V. (2005). A neurobehavioral model of affiliative bonding: Implications for conceptualizing a human trait of affiliation. *Behavioral and Brain Sciences*, *28*, 313-349.

DeSteno, D., Gross, J.J. and Kubzansky, L. (2013). Affective science and health: The importance of emotion and emotion regulation. *Health Psychology*, *32*, 474-486.

Engel, G.L. (1977). The need for a new medical model: a challenge for biomedicine. *Science*, *196*, 129-136.

Fonagy, P. (2018). *Affect regulation, mentalization and the development of the self*. Routledge.

Frankish, H., Boyce, N., & Horton, R. (2018). Mental health for all: a global goal. *The Lancet*, 392, (10157), p. 1493-1495. http://dx.doi.org/10.1016/ S0140-6736(18)32271-2

Fredrickson, B.L. (1998). What good are positive emotions? *Review of General Psychology*, *2*, 300.

Gallagher, S. (2005). *How the body shapes the mind.* Oxford University Press, Oxford.

Gidlow, C. J., Jones, M. V., Hurst, G., Masterson, D., Clark-Carter, D., Tarvainen, M. P., Smith, G. & Nieuwenhuijsen, M. (2016). Where to put your best foot forward: Psycho-physiological responses to walking in natural and urban environments. *Journal of Environmental Psychology*, *45*, 22-29.

Gross, J. J. (2013). Emotion regulation: taking stock and moving forward. *Emotion*, *13*, 359.

Gross, J. J., & Muñoz, R. F. (1995). Emotion regulation and mental health. *Clinical psychology: Science and practice*, *2*(2), 151-164.

Gilbert, P. ed. (2005). *Compassion: Conceptualisations, research and use in psychotherapy*. Routledge, Hove.

Gilbert, P. (2014). The origins and nature of compassion focused therapy. *British Journal of Clinical Psychology*, *53*, 6-41.

Gross, J.J. (2013). Emotion regulation: taking stock and moving forward, *Emotion*, 13, 3, 359-365.

Hart, K.E., Wilson, T.L. and Hittner, J.B. (2006). A psychosocial resilience model to account for medical well-being in relation to sense of coherence. *Journal of Health Psychology*, *11*, 857-862.

Hartig, T., van den Berg, A.E., Hagerhall, C.M., Tomalak, M., Bauer, N., Hansmann, R., Ojala, A., Syngollitou, E., Carrus, G., van Herzele, A. and Bell, S. (2011). Health benefits of nature

experience: Psychological, social and cultural processes. In Nilsson, K. et al. (Ed.). *Forests, trees and human health*, Springer, Dordrecht.

HM Government (2018). *A Green Future: Our 25 Year Plan to Improve the Environment,* available at: http://www.gov.uk/government/publications/25-year-environment-plan (accessed 26 April 2018).

Ikei, H., Song, C. and Miyazaki, Y. (2017). Physiological effects of touching wood. *International Journal of Environmental Research and Public Health*, 14, 801.

Johnsen, S.Å.K. and Rydstedt, L.W. (2013). Active use of the natural environment for emotion regulation. *Europe's Journal of Psychology*, *9*, 798-819.

Jordan, M. (2009). Nature and self—An ambivalent attachment? *Ecopsychology*, *1*, 26-31.

Joye, Y., & Van den Berg, A. (2011). Is love for green in our genes? A critical analysis of evolutionary assumptions in restorative environments research. *Urban Forestry & Urban Greening*, *10*(4), 261-268.

Kaplan, S. (1995). The restorative benefits of nature: Toward an integrative framework. *Journal of Environmental Psychology*, *15*, 169-182.

Kobayashi, H., Song, C., Ikei, H., Kagawa, T., & Miyazaki, Y. (2015). Analysis of Individual Variations in Autonomic Responses to Urban and Forest Environments. *Evidence-Based Complementary and Alternative Medicine*, *2015*.Korpela K. M., Pasanen T., Repo V., Hartig T., Staats H., Mason M., Alves S., Fornara F., Marks T., Saini S., Scopelliti M., Soares A.L., Stigsdotter U. K. and Ward Thompson C. (2018) Environmental Strategies of Affect Regulation and Their Associations With Subjective Well-Being. *Frontiers Psychology*. (9)562. doi: 10.3389/fpsyg.2018.00562

Kubzansky, L.D., Park, N., Peterson, C., Vokonas, P. and Sparrow, D. (2011). Healthy psychological functioning and incident coronary heart disease: the importance of self-regulation. *Archives of General Psychiatry*, *68*, 400-408.

Kühn, S., Düzel, S., Eibich, P., Krekel, C., Wüstemann, H., Kolbe, J., Martensson, J., Goebel, J., Gallinat, J., Wagner, G.G. and Lindenberger, U. (2017). In search of features that constitute an enriched environment in humans: Associations between geographical properties and brain structure. *Scientific Reports*, *7*, 11920.

Kuo, M. (2015). How might contact with nature promote human health? Promising mechanisms and a possible central pathway. *Frontiers in Psychology*, *6*, 1093.

Lakoff, G. and M. Johnson. (1999). *Philosophy in the flesh: The embodied mind and its challenge to western thought.* Basic Books, New York, NY.

LeDoux, J.E. (1998). *The emotional brain: The mysterious underpinnings of emotional life,* Simon and Schuster. New York, NY.

Maller, C., Townsend, M., Pryor, A., Brown, P. and St Leger, L. (2006). Healthy nature healthy people: 'contact with nature' as an upstream health promotion intervention for populations. *Health Promotion International*, 21, 45-54.

Marsland, A.L., Pressman, S., & Cohen, S. (2007). Positive affect and immune function. In Ader, R. (Ed.). *Psychoneuroimmunology* (4th edn.). Elsevier, San Diego, CA.

Mayer, F. S., & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of environmental psychology*, *24*(4), 503-515.

Merleau-Ponty, M., (1968). *The visible and the invisible: Followed by working notes.* Northwestern University Press, Evanston, Il.

Markevych, I., Schoierer, J., Hartig, T., Chudnovsky, A., Hystad, P., Dzhambov, A. M., ... & Lupp, G. (2017). Exploring pathways linking greenspace to health: theoretical and methodological guidance. *Environmental research*, *158*, 301-317.

McMahan, E. A., & Estes, D. (2015). The effect of contact with natural environments on positive and negative affect: A meta-analysis. The Journal of Positive Psychology, 10(6), 507-519.Odum, E. P. (1985). Trends expected in stressed ecosystems. *Bioscience*, *35*, 419-422.

Ohly, H., White, M. P., Wheeler, B. W., Bethel, A., Ukoumunne, O. C., Nikolaou, V., & Garside, R. (2016). Attention restoration theory: A systematic review of the attention restoration potential of exposure to natural environments. *Journal of Toxicology and Environmental Health, Part B*, *19*(7), 305-343.

Panksepp, J. (1998). *Affective neuroscience: The foundations of animal and human emotions.* Oxford University Press, New York, NY.

Perrin, J. L., & Benassi, V. A. (2009). The connectedness to nature scale: A measure of emotional connection to nature?. *Journal of Environmental Psychology*, *29*(4), 434-440.

Phelps, E.A. (2004). Human emotion and memory: interactions of the amygdala and hippocampal complex. *Current opinion in neurobiology*, 14, 198-202.

Porges, S.W. (1995). Orienting in a defensive world: Mammalian modifications of our evolutionary heritage. A polyvagal theory. *Psychophysiology*, 32, 301-318.

Porges, S.W. (2007). The polyvagal perspective. *Biological Psychology*, 74, 116-143.

Rabinowitz, P. M., Pappaioanou, M., Bardosh, K. L., & Conti, L. (2018). A planetary vision for one health. *BMJ global health*, *3*(5). e001137.

Richardson, M., Maspero, M., Golightly, D., Sheffield, D., Staples, V., & Lumber, R. (2017). Nature: a new paradigm for well-being and ergonomics. *Ergonomics*, *60*, 292-305.

Richardson, M., & McEwan, K. (2018). 30 Days Wild and the Relationships Between Engagement With Nature's Beauty, Nature Connectedness and Well-Being. *Frontiers in psychology*, *9*.

Richardson, M., McEwan, K., Maratos, F., & Sheffield, D. (2016). Joy and calm: how an evolutionary functional model of affect regulation informs positive emotions in nature. *Evolutionary Psychological Science*, *2*, 308-320.

Richardson, M., & Sheffield, D. (2017). Three good things in nature: noticing nearby nature brings sustained increases in connection with nature. *Psyecology*, *8*, 1-32.

Russell, R., Guerry, A.D., Balvanera, P., Gould, R.K., Basurto, X., Chan, K.M., Klain, S., Levine, J. and Tam, J. (2013). Humans and nature: how knowing and experiencing nature affect well-being. *Annual Review of Environment and Resources*, *38*, 473-502.

Sapolsky, R.M. (2007). Stress, stress-related disease, and emotional regulation, in Gross J. J. (Ed.). *Handbook of Emotion Regulation*, Guilford Press, New York, NY, 606-615.

Scherber C, Eisenhauer N, Weisser WW et al (2010). Bottom-up effects of plant diversity on multitrophic interactions in a biodiversity experiment. *Nature*, *468*, 553–556. doi: 10.1038/nature09492

Schultz, P. W. (2002). Inclusion with nature: The psychology of human-nature relations. In *Psychology of sustainable development* (pp. 61-78). Springer, Boston, MA.

Song, C., Igarashi, M., Ikei, H. and Miyazaki, Y. (2017). Physiological effects of viewing fresh red roses. *Complementary Therapies in Medicine*, *35*, 78-84.

Stevens, P. (2010). Embedment in the Environment: A New Paradigm for Well-being? *Perspectives in Public Health, 130,* 265-269.

Thompson, E. (2010). *Mind in life: Biology, phenomenology, and the sciences of mind*, Harvard University Press, Cambridge.

Tinbergen, N. (1951). The study of instinct.

Tugade, M.M. and Fredrickson, B.L. (2007). Regulation of positive emotions: Emotion regulation strategies that promote resilience. *Journal of Happiness Studies*, *8*, 311-333.

Tzoulas, K., Korpela, K., Venn, S., Yli-Pelkonen, V., Kaźmierczak, A., Niemela, J., & James, P. (2007). Promoting ecosystem and human health in urban areas using Green Infrastructure: A literature review. *Landscape and urban planning*, *81*, 167-178.

Ulrich, R. S. (1983). Aesthetic and affective response to natural environment. In Behavior and the natural environment (pp. 85-125). Springer US.

Ulrich, R.S., Simons, R.F., Losito, B.D., Fiorito, E., Miles, M.A. and Zelson, M. (1991). Stress recovery during exposure to natural and urban environments, *Journal of Environmental Psychology. 11*, 201-230.

Van Gordon, W., Shonin, E., Diouri, S., Garcia-Campayo, J., Kotera, Y., & Griffiths, M. D. (2018). Ontological addiction theory: Attachment to me, mine, and I. *Journal of behavioral addictions*, 1-5.